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# CHAPTER 1 The Biological Criteria Program and Guidance Documents

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Efforts to measure and manage water quality in the United States are an evolving process. Since its simple beginning more than 200 years ago, water monitoring has progressed from observations of the physical impacts of sediments and flotsam to chemical analyses of the multiple constituents of surface water to the relatively recent incorporation of biological observations in systematic evaluations of the resource. Further, although biological measurements of the aquatic system have been well-established procedures since the Saprobic system was documented at the turn of this century, such information has only recently been incorporated into the nation's approach to water resource evaluation, management, and protection.

The U.S. Environmental Protection Agency (EPA) is charged in the Clean Water Act (Pub. L. 100-4, §101) "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." To incorporate biological integrity into its monitoring program, the Agency established the Biological Criteria Program in the Office of Water.

This program provides technical guidance to the states for measuring biological integrity as an aspect of water resource quality. Biological integrity complements the physical and chemical factors already used to measure and protect the nation's surface water resources. Eventually all surface water types will be included in program technical guidance, including streams, rivers, lakes and reservoirs, wetlands, estuaries, and near coastal marine waters.

States will use this information to establish biological criteria or benchmarks of resource quality against which they may assess the status of their waters, the relative success of their management efforts, and the extent of their attainment or noncompliance with regulatory conditions or water use permits. These criteria are intended to augment, not replace, other physical and chemical methods, to help refine and enhance our water protection efforts.

## The Concept of Biological Integrity

Biological integrity is the condition of the aquatic community inhabiting unimpaired waterbodies of a specified habitat as measured by community structure and function (U.S. Environ. Prot. Agency, 1990).

Essentially, the concept refers to the naturally dynamic and diverse population of indigenous organisms that would have evolved in a particular area if it had not been affected by human activities. Such integrity or naturally occurring diversity becomes the primary reference condition or source of biological criteria used to measure and protect all waterbodies in a particular region.

Only the careful and systematic measuring of key attributes of the natural aquatic ecosystem and its constituent biological communities can determine the condition of biological integrity. These key attributes or biological endpoints indicate the quality of the waters of concern. They are established by biosurveys — by analyses based on the sampling of fish, invertebrates, plants, and other flora and fauna. Such biosurveys establish the endpoints or measures used to summarize several community characteristics such as taxa richness, numbers of individuals, sensitive or insensitive species, observed pathologies, and the presence or absence of essential habitat elements.

The careful selection and derivation of these measures (hereafter, metrics), together with detailed habitat characterization, is essential to translate the concept of biological integrity into useful biological criteria. That is, the quantitative distillation of the survey data makes it possible to compare and contrast several waterbodies in an objective, systematic, and defensible manner.

## *Narrative and Numeric Biological Criteria*

Two forms of biological criteria are used in EPA's system of water resources evaluation and management.

■ **Narrative biological criteria** are general statements of attainable or attained conditions of biological integrity and water resource quality for a given use designation. They are qualitative statements of intent — promises formally adopted by the states to protect and restore the most natural forms of the system. Narrative criteria frequently include statements such as "the waters are to be free from pollutants of human origin in so far as achievable," or "to be restored and maintained in the most natural state." The statements must then be operationally defined and implemented by a designated state agency.

■ **Numeric criteria** are derived from and predicated on the same objective status as narrative criteria, which are then retained as preliminary statements of intent. The difference between the two is that the qualitative statement of integrity, the condition to be protected or restored, is refined by the inclusion of quantitative (numeric) endpoints as specific components of the criteria. Compliance with numeric criteria involves meeting stipulated thresholds or quantitative measures of biological integrity.

The formal adoption of criteria of either type into state law (with EPA concurrence) makes the criteria "standards." They are then applicable and enforceable under the provisions of the Clean Water Act.

### ***Biological Criteria and Water Resource Management***

Because these criteria will become the basis for resource management and possible regulatory actions, the manner of their design is of utmost importance to the states and EPA. The choice of metrics to represent and measure biological integrity is the responsibility of ecologists, biologists, and water resource managers. The Agency's role is to continue to develop technical guidance documents and manuals to assist in this process.

The purpose of this document is to present methods that will help managers interpret and gauge the confidence with which the criteria can be used to make resource management decisions. Using this guidance, both the technician and the policymaker can objectively convert data into management information that will help protect water resources. However, the use and limits of the information must be clearly understood to ensure coordination and mutual cooperation between science and management.

### **An Overview of this Document**

The focus of this document is on the basic statistical concepts that apply within the biocriteria program. From the program's inception, the problem statement, survey design, and the statistical methods used in the analysis must be correlated to provide functional re-

sults. Accordingly, chapter 2 begins with formulations of the problem statement — the focused objective that helps narrow the scope of observations in the ecosystem to those necessary to predict the status and impairment of the biota — and culminates in a discussion of hypothesis testing, the approach advocated in this guidance document. Chapter 2 also refers beginners to Appendix A for a succinct review of the basic statistics and statistical concepts used within the chapter and throughout this document.

Chapter 3 presents key issues associated with the design of the sample survey. Surveys are without doubt the critical element in an environmental assessment. Designs that minimize error, uncertainty, and variability in both biological and statistical measures have a great effect on decision makers. This chapter explores the difference between classical and experimental design and the issues involved with random, systematic, and stratified samples. Sample sizes and how to proceed in confusing circumstances round out the discussion.

Chapter 4 deals with problems that arise from hypothesis testing methods based on detecting the mean differences arising from two or more independent samples. The use and abuse of means testing procedures is an important topic. It should generally be keyed to the survey design, but other information should also be taken into consideration because errors of interpretation often involve assumptions about data.

Chapter 5 is a further discussion, with examples, of the basic concepts introduced in earlier chapters. Though hypothesis testing is generally preferred, this chapter discusses circumstances in which other procedures may be useful. It also introduces the role of cost-benefit assumptions in decision analysis and the limits of data collection and interpretation in the determination of causality. The reader should recall at all times the basic nature of this document. Advanced practitioners may look to the references used in preparing this document for additional options and discussion.